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INDUSTRIAL RESEARCH & DEVELOPMENT

MARCH 1980

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Colorimetry with a spectrophotometer

Who earns what in R&D?

Where we're going in energy research

(Economical) interactive image analysis

Here's what's new in metallurgical coatings

plus: Our unique news section for people in R&D

INDUSTRIAL RESEARCH & DEVELOPMENT

SERVING THE $107-BILLION WORLD-WIDE R&D INDUSTRY

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approx. 3,000 copies to nonqualified readers contain pp. 2A and 2B.

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In the 0/45-deg spectrophotometer, the continuous interface wedge filter, hermetically sealed in glass, allows continuous scanning of the spectrum within the range of 380 to 710 nm. The band pass is approximately 2.5% of the center wavelength. For example, at 400 nm, the total band pass is 10 nm. An article about spectrophotometric color determination begins on p. 126 in this issue.

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Technical Publishing

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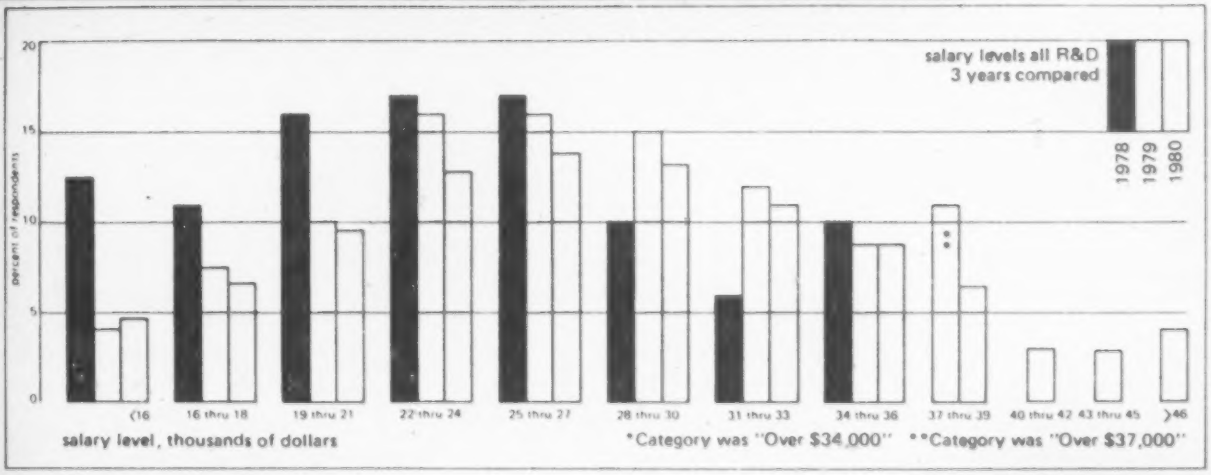
ABP BPA

Robert R. Jones
Editor

Bigger pay checks, less buying power for people in R&D



Clear evidence that salaries are going up in R&D can be seen on this chart. We have added three new salary ranges at the top and still end up with a bulge in the highest category where it should taper off.

Readers continue to report steadily increasing salaries, but rate of increase appears to have slowed and many people in R&D find their gains have been mostly on paper.

SALARIES ARE UP in research, development, and quality assurance—they definitely are up. There is a 29.5% increase in the number of persons earning more than $37,000 per year, and there are declines in the percentages of persons reporting lower salary ranges.

Enthusiasm must be tempered, however, by the very-strong likelihood, if not actual certainty, that average salaries in research, development, and quality assurance have not kept pace with inflation.

These conclusions are drawn from our annual survey of readers which this year produced usable responses from 5,158 scientists and engineers.

The accompanying chart, "Salary levels all R&D," illustrates the distribution of scientists and engineers in 12 salary ranges over the three past years. Perhaps as notable as any other information portrayed on the chart is the fact that highest range in 1978 was "Over $34,000." For 1980's report, we have extended the ranges to "more than $46,000," and this new upper level now contains almost half as many respondents as the "Over $34,000" did just two years ago.

In 1978 we reported that "many of these gains are more apparent than real." This year, such a statement can be repeated. Unlike last year when median income for all respondents had increased nearly 13% from the 1978 figure and more than covered inflation, this year's median salary for all respondents, at $28,476, is only 3.5% higher than last year's.

In the battle against inflation, it is noteworthy that 37.2% of this year's respondents are earning more than $31,000 annually, up from 32% last year and a mere 13% in 1978. It does appear, however, that the salary range for persons working in research, development, and quality assurance has been stretched out. While the crowd at the top has gotten larger, the

number at the low end is no smaller. In 1979, 4% were earning less than $16,000 per year, and the number is even a bit larger than that this year. Back in 1978, though, there were three times as many in that salary range.

More than half of the 5,000-plus respondents received a salary increase of 6% through 9% during the past year. This is higher than the number getting such raises in our 1979 report, but so is the inflation figure larger than for 1979's.

Some 8.8% received raises of 14% or more in the past year; only 6% of the last year's respondents exceeded 14%.

Increases were not evenly distributed throughout the professions. Details for six different parameters by professions are shown in the charts. The differences by profession have caused some shifting in the rankings. Information received in this most-recent survey leads to the following rankings by median salary:

Rank	Profession	No. responding	Median salary
1	Mathematician	37	$33,099
2	Aero. Engr.	73	32,226
3	Physicist	458	$31,050
4	Metallurgist	227	30,228
5	Elec. Engr.	555	29,635
6	Mech. Engr.	500	29,480
7	Chem. Engr.	404	29,272
8	Chemist	1,875	27,031
9	Indust. Engr.	57	26,649
10	Other	629	26,118
11	Biologist	226	25,561

Biologists, last on the above list, clearly lead the ranks in the area of advanced degrees. Fifty-four percent of the biologists have PhDs compared to only 8.8% for the industrial engineers. For all respondents, 28.2% have a PhD, 25.7% master's, 38.2% bachelor's, and 7.9% less than bachelor's. Salary for education for all respondents for this year and two previous years is shown in a chart.

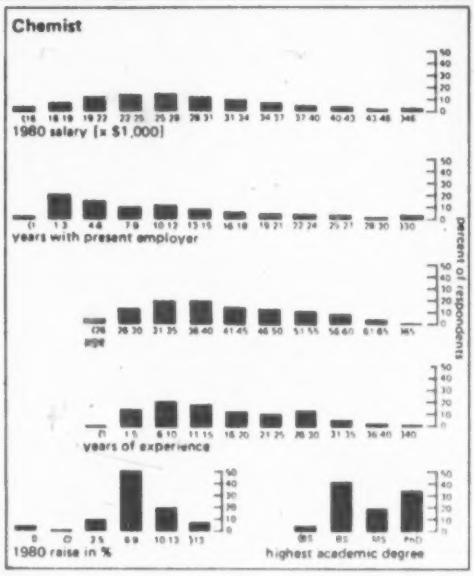
The dollar value of an advanced degree obviously varies by profession. For the R&D industry as a whole, median salaries by highest academic degree are:

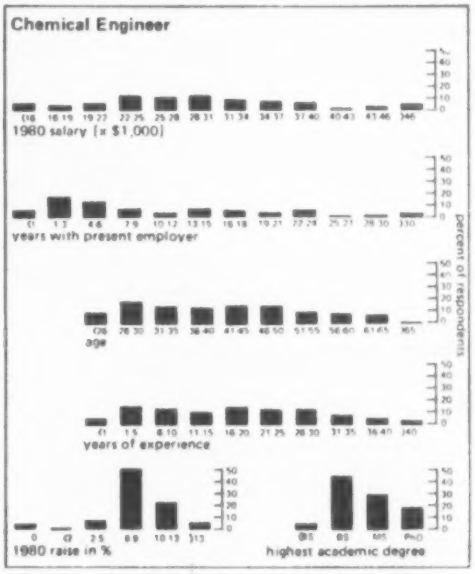
Degree	Median salary	Difference over next lower degree
Doctorate	$32,252	$3,876
Master's	28,376	2,067
Bachelor's	26,309	3,310
< Bachelor's	22,999	

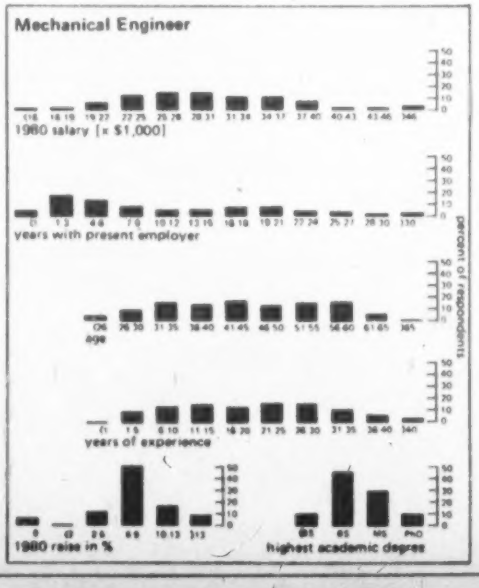
As you can see, the advantage for a PhD over less-than-bachelor's, based on these medians, is $9,253, and for PhD over bachelor's, is $5,943.

If we assume a 25-year career, not at all out of line according to reports from this year's respondents, charted elsewhere, and an interest rate of 7.5%, the advantage of the doctorate over the MS is in the neighborhood of $285,000. MS over BS could be worth more than $150,000 under the same conditions, and BS over less than BS would be worth more than $240,000.

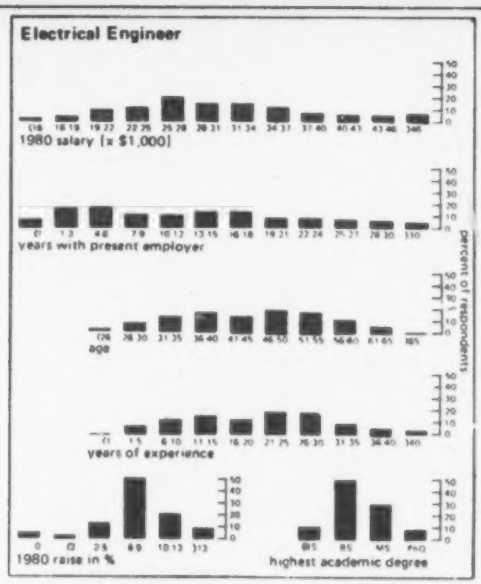
Taken as a direct benefit on the basis just

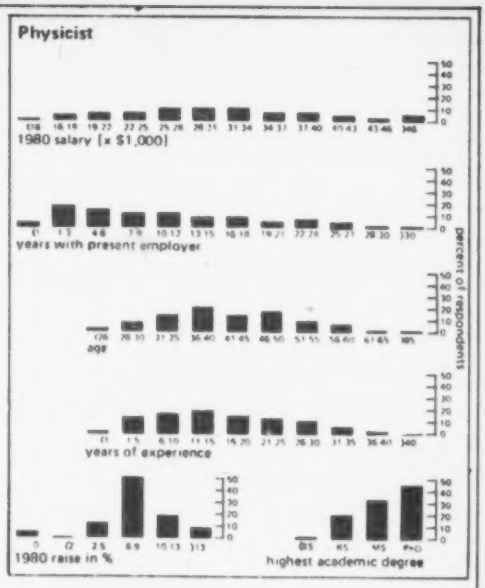


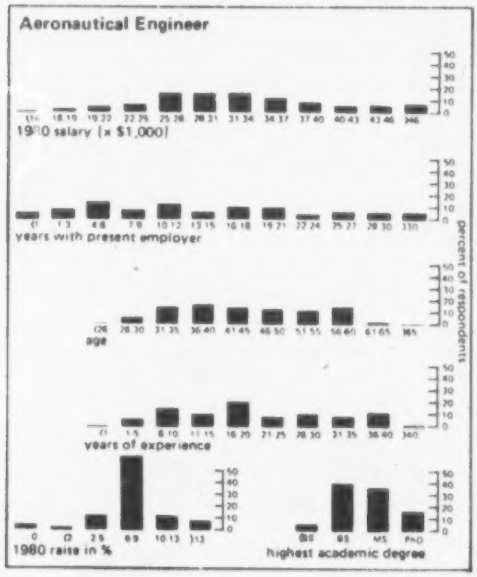


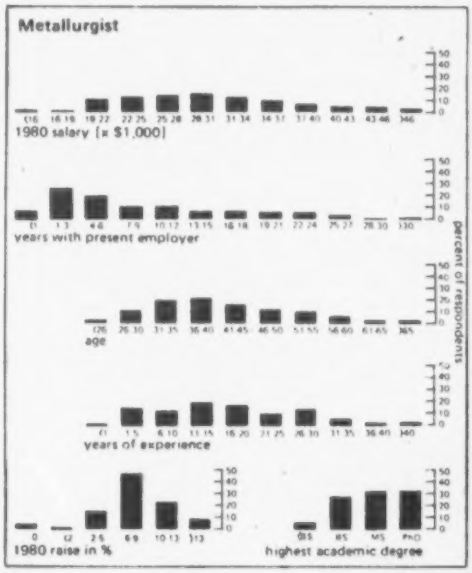


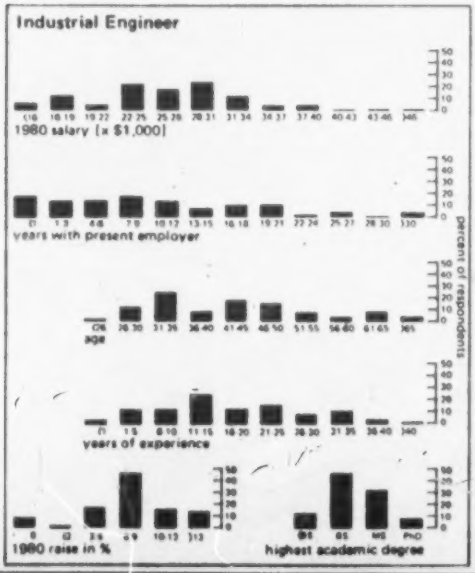
On these two pages and on page 108 you have an opportunity to compare the details of salary by ranges, years of experience, age, highest degrees held, years with present employer, and raise during the past year for each of the professional groups surveyed. The comparisons reveal some significant differences.

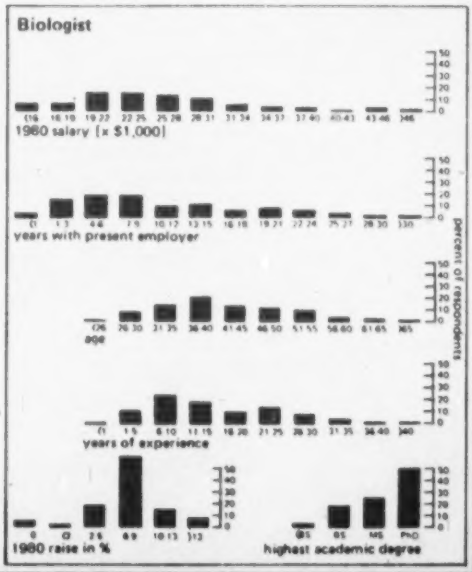

Electrical Engineer
1980 salary [x $1,000]
years with present employer
age
years of experience
1980 raise in %
highest academic degree
percent of respondents

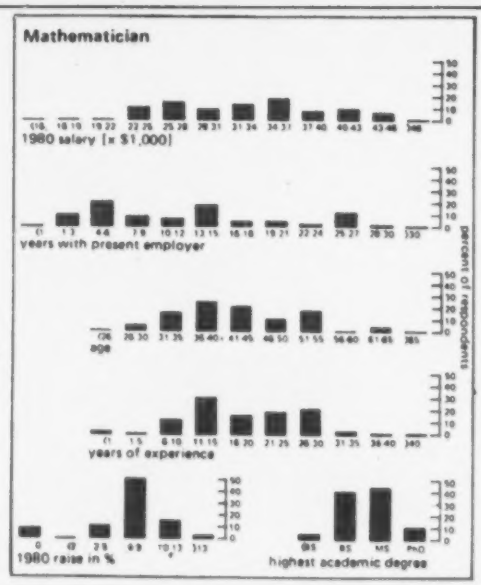

Physicist
1980 salary [x $1,000]
years with present employer
age
years of experience
1980 raise in %
highest academic degree
percent of respondents

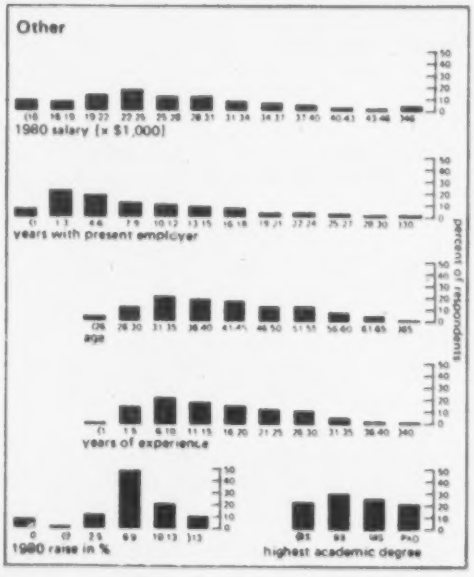

Aeronautical Engineer
1980 salary [x $1,000]
years with present employer
age
years of experience
1980 raise in %
highest academic degree
percent of respondents


Metallurgist
1980 salary [x $1,000]
years with present employer
age
years of experience
1980 raise in %
highest academic degree
percent of respondents


Industrial Engineer
1980 salary [x $1,000]
years with present employer
age
years of experience
1980 raise in %
highest academic degree
percent of respondents


Biologist
1980 salary [x $1,000]
years with present employer
age
years of experience
1980 raise in %
highest academic degree
percent of respondents





stated, the advantage in annual salary for a PhD when compared to a bachelor's, would provide a career gain of just under $440,000. Even allowing $165,000 for five additional income years for the person who starts working at the end of four years' college and to cover tuition for the PhD, the advantage to the latter still is in the neighborhood of $275,000.

The advantage of a doctorate has increased strikingly in recent years. In both 1976 and 1977, our respondents placed the annual advantage at approximately $2,200. In 1978 it dropped to $2,000. Last year we could report a benefit of $3,300, and as noted above, this year the advantage is $3,876 as an average for all R&D.

This fact is emphasized by looking at the breakdown by degrees in the upper salary ranges for all respondents:

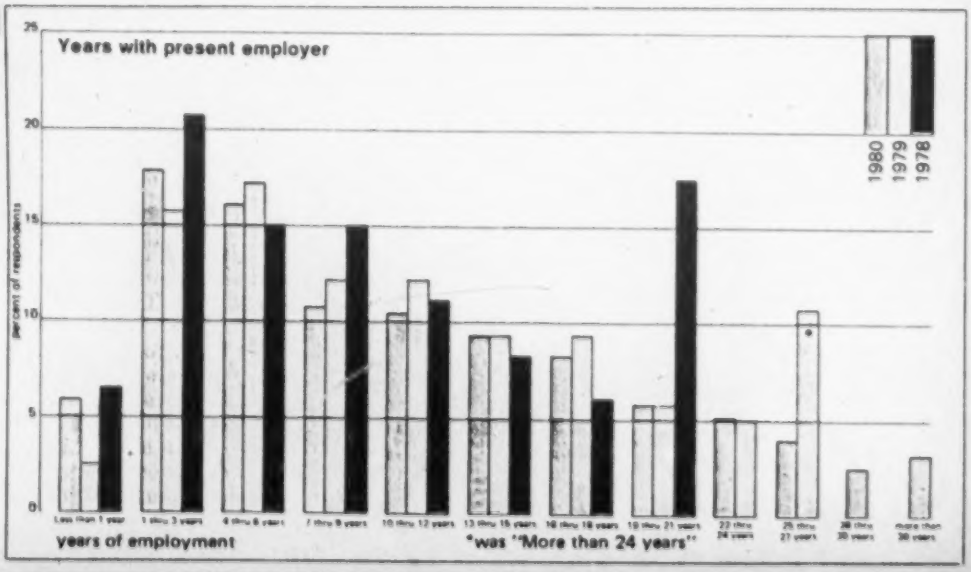
	Distribution of degrees			
Group	BS	BS	MS	PhD
All responding	7.9%	38.2%	25.7%	28.2%
$40,000 to $42,999	1.6	24.4	22.8	51.1
$43,000 to $45,999	2.1	28.9	23.9	45.1
More than $46,000	3.4	21.6	18.6	56.4

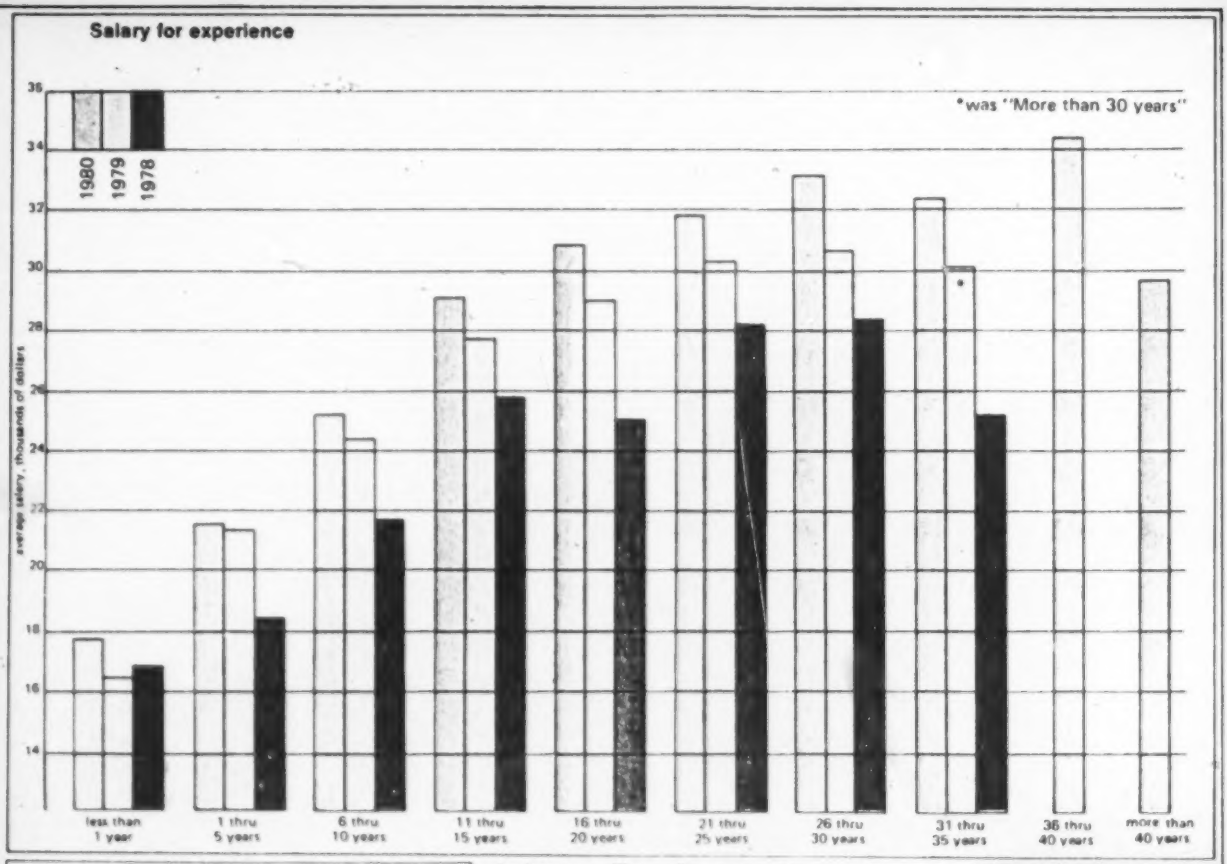
One could assume that if academic degree were not a factor in the above placings, distribution of degrees in all salary ranges would be the same as the distribution for the total respondents.

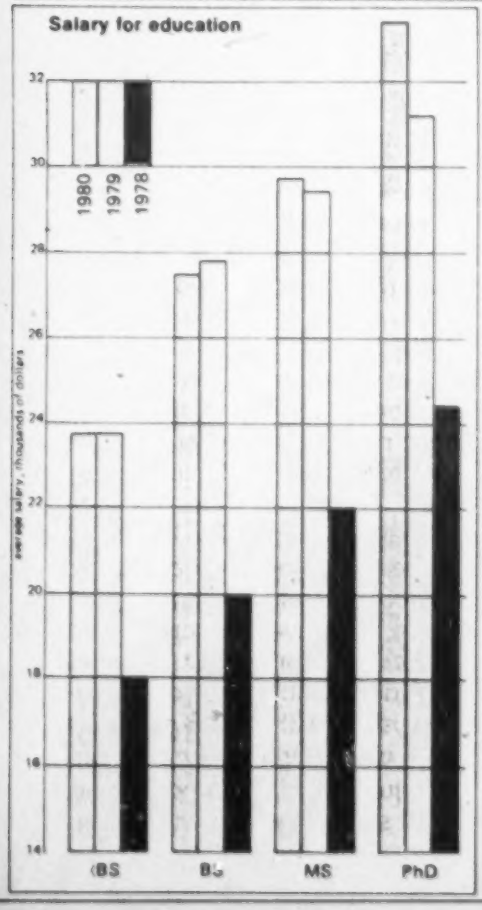
Looking at the question of age, one begins to wonder whether the field of physics is being replenished, whether the latest ideas are being brought into the ranks, and—possibly—whether there might be an indication here that physics would offer a great opportunity for a person now starting to college.

We say this because fewer than 10% of all physicists are younger than 31, if our respondents are representative of the R&D

In a nation known for mobility, U.S. R&D workers are surprisingly stable. As with our salary chart, we have had to add to the upper ranges in this chart showing the number of years with the present employer.







industry. For all respondents there are 14.1% in that younger-than-31 age group, and chemical engineers are an especially youthful group, with 23% being 30 or younger.

Across the board, 62% are between the ages of 30 and 51.

A possible indication of changed retirement policies may have showed up in this year's survey. Whereas last year, none of the professional categories had more than 1% in the older-than-65 age groups, this year three categories do.

Industrial engineers have the highest percentage over 65, at 3.5%, but with only 57 respondents, that means two people. It's hard to project such figures with great confidence. However, 4 of the 227 metallurgists and 9 of the 500 mechanical engineers are in that age group, for 1.8% in each case, and a closer approach to confidence in the figures.

Much additional information about the people who work in research, development, and quality assurance is provided in the charts which accompany this text.

In the second part of this salary report we will present the salary picture as provided by the same 5,000-plus respondents when broken into categories of sex and workplace.

When you read that second article you will see that other important changes are occurring in the R&D industry, and you will be able to read types of information which we have not been able to derive in previous years. □

Employers pay for experience and education. In the charts on this page we have tried to show the benefits separately. Benefits that accrue to a PhD are extrapolated over a 25-year career in the text.

1980 APRIL

INDUSTRIAL RESEARCH & DEVELOPMENT

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APRIL 1980

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Data acquisition for the GPC user

Detecting N- and P-compounds with gas chromatography

Workplace and sex as salary factors in R&D

Monitoring and diagnosing high-vacuum processes

News for the people who work in R&D

INDUSTRIAL RESEARCH & DEVELOPMENT

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ABOUT THE COVER

Microparticulate packings have provided column efficiencies of more than 60,000 theoretical plates per meter. Choice of appropriate column and mobile phase permits reversed-phase separations of most materials.

M.L. Van Kavelaar, DuPont electron microscopist, has prepared the 5,000X micrograph of "Zorbax" TMS particles — increased another 6.5X for this cover.

An article on column packing selection begins on p. 99 in this issue.

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ABP BPA

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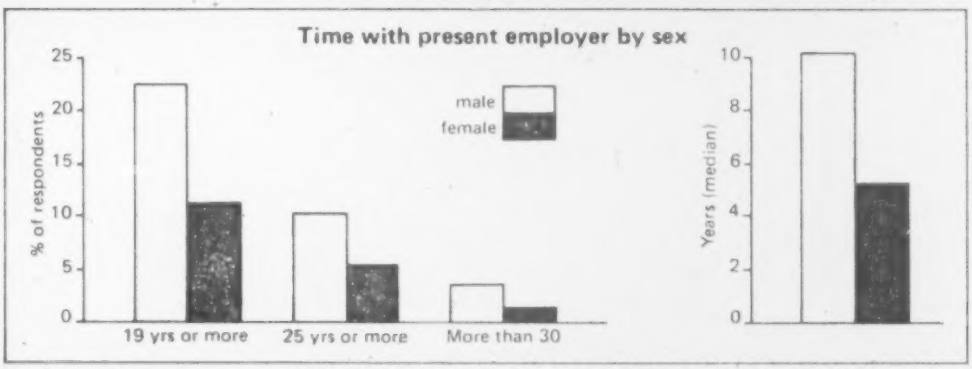
Robert R. Jones
Editor

For pay alone, it's male, PhD, working for the government



Salary differences in R&D which can be explained only by sex are getting harder to find as women get a large portion of the bigger raises and add to their experience and academic achievements.

WOMEN IN R&D earn a lot less than men do. This is neither new nor surprising. And, where there have been areas of discrimination, there is some sign that efforts are being made to end it.

It's easy to oversimplify such a subject, but basically what women in R&D need to do in order to earn as large salaries as men in R&D is get more experience, get more education, and accumulate more years with their present employer.

Sex, however, is only one area where education, age, years of experience, and number of years with present employer don't seem to carry equal weight. The nature of the workplace also makes a notable salary difference. Government pays more than industry and both pay more than do universities.

When all of the differences apply, we find that the male R&D worker in government is earning a median annual salary of $30,123 in contrast to the female R&D worker in a university where the median annual salary would be $17,123.

This salary information is derived from the responses of more than 5,000 of our readers to our annual salary survey. The first portion of this report appeared in the March issue, and dealt primarily with R&D-wide data and data broken out by professions.

In this concluding article, we will look, for the most part, at considerations of salary for R&D workers by sex and workplace. A year ago we presented this type of information for the first. This year we have approached the report with nearly twice as many respondents and with more correlations ordered out of our computer.

Getting back to those median salaries for R&D workers, we find that they are, when ranked from highest to lowest,

Men in government	$30,123
Men in industry	28,804
Men in universities	26,070
Women in government	24,786
Women in industry	20,372
Women in universities	17,123

In our study, the median for all males in R&D is $28,711 and for all females, $20,756. These figures are close to the industry figures because industry provides the most jobs in R&D.

An interpretation of any significance in these median figures requires careful looks at a variety of parameters. As we mentioned at the beginning, women not only lag in salaries, they also lack many of

the factors which lead directly to larger salaries for persons of either sex.

Experience is such a factor. The median experience for the male respondents to this survey is 16.97 years; for the female respondents it is 8.14 years. Of the men, 38.3% had more than 20 years' experience. Only 16.1% of the women had as much. And 520 of the men responding, 10.9% of the total, had more than 30 years' experience.

You will remember from the chart in last month's issue that experience is a strong factor in size of salary. The latest salary-for-experience figures for 6 through 10 years (which includes the women's median) is right at $25,000 for both sexes. The figure for the 16 through 20-year range (including the men's median experience) is close to $31,000 for both sexes. It just happens that, for good and understandable reasons, there are more women in the brackets with the least experience.

In terms of education, we have seen over the years the benefits in the paycheck of advanced degrees. This year's premium (see March report) for a PhD over a BS for both sexes is $5,943. This can easily amount to a career advantage for the PhD of at least $275,000. But most of the PhDs are held by men. Of our 5,000-plus respondents, 95.1% were male and 4.9% were female. Distribution of sexes by academic degrees is as follows:

	male	female
Less than bachelor's	96.1%	3.9%
Bachelor's	93.2	6.8
Master's	95.1	4.9
Doctorate	97.6	2.4

In most organizations longevity (time with that employer) is valuable. In some, it is everything. Again, for whatever reasons, men are in the positions to earn the benefits from longevity.

Our chart showing sex vs. time with present employer makes this obvious. Men, with a median of 10.1 years nearly double women's longevity at 5.28 years. And, because we have extended our scale for this year's survey, we can tell you for the first time that 3.4% of the men responding to this survey have worked for their present employer for more than 30 years. Half that proportion of the women are in that longevity of range, at 1.7%. However, even this longevity strength for women does not

Percentage of respondents by sex in each salary range

	No. responded	% male	% female
Total	5,034	95.1	4.9
Less than $16,000 per year	241	80.0	20.0
$16,000 to $18,999	347	84.0	16.0
$19,000 to $21,999	497	91.7	8.3
$22,000 to $24,999	659	93.5	6.5
$25,000 to $27,999	719	96.6	3.4
$28,000 to $30,999	681	97.8	2.2
$31,000 to $33,999	567	98.4	1.6
$34,000 to $36,999	457	99.1	0.9
$37,000 to $39,999	328	99.1	0.9
$40,000 to $42,999	190	98.4	1.6
$43,000 to $45,999	142	100.	0.0
More than $46,000 per year	206	98.5	1.5

Where R&D scientists and engineers work

Discipline	No. responded	% industry	% govt.	% univ.
Total responding	5,041	74.5	16.1	9.4
Chemists	1,875	79.7	14.0	6.3
Chemical engineers	404	85.6	10.4	4.0
Mechanical engineers	500	78.4	15.7	5.8
Electrical engineers	555	73.9	16.6	9.4
Aeronautical engineers	73	64.4	28.8	6.8
Industrial engineers	57	75.4	14.0	10.5
Physicists	458	58.5	25.8	15.5
Metallurgists	227	84.8	11.6	3.6
Biologists	226	46.5	19.5	34.1
Mathematicians	37	81.1	18.9	0.0
Other	629	68.4	17.8	13.8

change the fact that the bulk of women in R&D are at the low end of the longevity scale.

All of these factors that help to explain the differences in salaries for men and women in this field, do not completely justify the differences. That there has been sex discrimination is obvious, and we joined that issue at some length last year (Editorial and article, April *IR&D*).

Women did far better than men in the area of raises during the period covered by this survey. Although only 4.9% of the respondents are women, 7.5% of all raises of 14% or more went to women.

Looked at the other way, this means that one out of every seven women received a raise of 14% or more last year. Or, better than one out of every three women received a raise of 10% or more—well above the national guidelines. Considering all of the other factors reported here, a portion of these increases to women can be attributed to sex-vs.-salary adjustments.

Variations from a directly proportional distribution by sex in each salary range can be seen in the accompanying table.

The old idea that Uncle Sugar pays the best wages is hard to stomp out. That probably is because surveys such as this one tend to support that old idea.

In this study we learned that median salaries for R&D workers of both sexes were:

Government	$29,733
Industry	28,354
University	25,685

And while you might point out (correctly) that there are proportionately more women working in the universities, we would counter with the fact that there is a substantially higher proportion of PhDs in the universities, and we have demonstrated earlier the salary advantages of the PhD degree.

An accompanying table shows you the tally of R&D scientists and engineers by discipline in industry, government, and university among our 5,000 respondents. Following are the responses to our Opinion Poll Questionnaire from all 5,000-plus respondents and for the 4.9% of all respondents who are female. Since male represents 95.1% of all responses, we are not showing male separately.

	All R&D	Female R&D
1. What is your annual salary (thousands)?		
a. Less than $16	4.8%	18.2%
b. $16 thru $18	6.9	21.9
c. $19 thru $21	9.9	16.9
d. $22 thru $24	13.0	17.8
e. $25 thru $27	14.3	9.9
f. $28 thru $30	13.5	6.2
g. $31 thru $33	11.3	3.7
h. $34 thru $36	9.0	1.7
i. $37 thru $39	6.5	1.2
j. $40 thru $42	3.4	1.2
k. $43 thru $45	2.9	0.0
m. More than $46	4.1	1.2
2. Your raise during the past year was...		
a. none	5.7%	6.3%
b. Less than 2%	1.5	1.3
c. 2 thru 5%	12.4	10.8
d. 6 thru 9%	52.0	44.8
e. 10 thru 13%	19.5	22.9
f. 14% or more	8.8	13.7
3. How many years have you worked for your present employer?		
a. Less than 1	5.9%	8.3%
b. 1 thru 3	18.2	32.2
c. 4 thru 6	16.3	22.3
d. 7 thru 9	10.9	10.3
e. 10 thru 12	10.4	7.0
f. 13 thru 15	9.2	4.1
g. 16 thru 18	7.9	5.0
h. 19 thru 21	5.9	4.1
i. 22 thru 24	5.2	1.7
j. 25 thru 27	4.2	1.7
k. 28 thru 30	2.5	1.7
m. More than 30	3.3	1.7
4. What is your age?		
a. Under 26	3.4%	14.0%
b. 26 thru 30	10.7	30.6
c. 31 thru 35	17.1	21.1
d. 36 thru 40	17.7	11.2
e. 41 thru 45	14.0	7.9
f. 46 thru 50	13.1	2.5
g. 51 thru 55	11.5	7.9
h. 56 thru 60	8.3	3.7
i. 61 thru 65	3.4	0.4
j. Over 65	0.8	0.8
5. How many years of experience do you have:		
a. Less than 1	1.3%	3.3%
b. 1 thru 5	12.9	36.8
c. 6 thru 10	17.2	23.1
d. 11 thru 15	17.3	12.4
e. 16 thru 20	14.0	8.3
f. 21 thru 25	13.2	5.8
g. 26 thru 30	13.4	5.8
h. 31 thru 35	6.0	3.7
i. 36 thru 40	3.4	0.8
j. More than 40	1.2	0.0
6. What is the highest degree you hold?		
a. Less than bachelor's	7.9%	6.2%
b. Bachelor's	38.2	53.7
c. Master's	25.7	26.0
d. Doctorate	28.2	14.0
7. What is your profession?		
a. Chemist	37.2%	57.4%
b. Chemical engr.	8.0	4.1
c. Mechanical engr.	9.9	0.8
d. Electrical engr.	11.0	2.9
e. Aeronautical engr.	1.5	0.4
f. Industrial engr.	1.1	1.7
g. Physicist	9.1	5.8
h. Metallurgist	4.5	2.9
i. Biologist	4.5	8.3
j. Mathematician	0.7	1.2
k. Other	12.5	14.0
8. Do you work in		
a. Industry	74.5%	78.1%
b. Government	16.1	13.6
c. University	9.3	7.0